

28 37. (Amended) The method of claim 15 wherein said contact pad is accessed by means of interconnect metal being provided in a plane of said contact pad and overlying said layer of dielectric.

38. (Amended) The method of claim 15 wherein said contact pad is accessed by means of at least one via provided through said layer of dielectric.

REMARKS

Examiner Lee, Hsien Ming is thanked for thoroughly reviewing the instant application and for examining the Prior Art.

Favorable reconsideration of this application in light of the above amendments and the following remarks is respectfully requested.

A new method is provided for the creation of metal bumps over surfaces of I/O pads. Contact pads are provided over the surface of a layer of dielectric. The aluminum of the I/O pads, which have been used as I/O pads during wafer level

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semiconductor device testing, is completely or partially removed over a surface area that is smaller than the surface area of the contact pad using methods of metal dry etching or wet etching. The contact pad can be accessed either by interconnect metal created in a plane of the contact pad or by via that are provided through the layer of dielectric over which the contact pad has been deposited. The process can be further extended by the deposition, patterning and etching of a layer of polyimide over the layer of passivation that serves to protect the contact pad.

#### Drawings

Reconsideration of the objection to the drawings is respectfully requested based on the following.

Fig. 19b has been amended with the addition of the Prior Art legend to this figure.

In light of the foregoing response, applicant respectfully requests that the Examiner's objection to the drawing be withdrawn.

Claim Objections

Reconsideration of the claim objections is respectfully requested based on the following.

Applicant respectfully agrees with Examiner that claims 28-31 and 34, 35 are redundant, these claims have been cancelled. Claims 36, 39 and 40 specify additional steps to claim 33 that have not previous been specified, following the chain of 15-32/39/40-33-36. It is kindly suggested by Applicant that these claims 36, 39 and 40 should therefore remain pending as part of the subject application.

In light of the foregoing response, applicant respectfully requests that the Examiner's objection to the claims be withdrawn.

Claim Rejections

Reconsideration of the rejection of claims 1, 2, 8, 9, 16, 17, 19, 29, 30 and 32 is respectfully requested based on the following.

The term "a measurable amount " has been replaced with the term "an amount" in claims 1, 2, 8, 9, 16, 17, 19, 29, 30 and 32 as kindly suggested by Examiner.

In light of the foregoing response, applicant respectfully requests that the Examiner's claim rejections be withdrawn.

Claim rejections - 35 U.S.C. § 103

Reconsideration of the rejection of claims 1-40 under 35 U.S.C 103(a) as being unpatentable over Applicant's Admitted Prior Art in combination with Jin (US Patent 6,194,309) and Dass et al (US Patent 6,162,652) is respectfully requested based on the following.

The Applicant's Admitted Prior Art (AAPA) does not disclose the essence of the instant invention, that is the complete or partial removal of the contact pad over surface areas of the contact pad that have potentially been damaged by tester probe contact.

Figs. 1a and 1b of the AAPA show how the surface of a contact pad can be damaged by repeated contacting this surface with a test probe, these figures show the problem without

providing any direct or indirect indication of or reference to the solution thereof that is provided by the instant invention.

Page 29 of the specification states:

"Prior art methods that are used to create a contact pad are further highlighted in Figs. 19a and 19b and in Figs. 20a through 20d. These figures also address methods that can be used for the interconnection of the contact pad. Although these methods of interconnection of contact pads are not part of the invention, a brief review of these methods at this time is considered of value."

This paragraph adequately highlights that Figs. 19a through 20d do not address nor provide for the solution to (test probe induced) surface damage that is provided by the instant invention. In none of the drawings that have been marked as Prior Art are shown contact pads that are in any way modified in order to removed a potentially damaged surface of a contact pad. The admitted Prior Art therefore does not refer to or suggest the solution provided by the instant invention, the AAPA merely describes aspects of Prior Art contact pad formation and aspects of how contact pads can be damaged by repeated impact of a test probe.

Jin provides for forming a contact capable of reducing the resistance between a contact pad and a buried contact.

Jin creates a conventional structure of CMOS devices, Fig. 2a, having source/drain regions, and creates an opening to a bit line contact of the dual CMOS devices. The opening is filled with a conductive material, creating what Jin refers to as a contact pad, the contact pad is electrically connected to the source/drain region of the CMOS devices.

A second insulating layer is deposited, Fig. 2A, patterned and etched, creating an opening that is aligned with the contact pad while also creating spacers over sidewalls of the opening. By now etching into the exposed surface of the contact pad, bounded by the spacers that have been formed over sidewalls of the opening, a recess region "a", Fig. 2A, is formed in the contact pad 112. This recess acts to increase the contact surface area available within the contact plug, thereby reducing the contact resistance.

A cleaning process is then applied, col. 4, lines 62, expanding dimensions of the opening that has been created in the contact pad, after which impurity ions are implanted to further

improve the impurity concentration at the top portion of the contact pad 112.

The contact hole is then, col. 5, lines 16, filled with conductive material, which is planarized to form a buried contact.

The Jin invention prevents, for devices of sub-miniature dimensions and there-with associated fine-pitch points of electrical contact, an increase in contact resistance in view of the smaller dimensions of the contact plug. This by expanding the surface areas between an underlying contact plug (making contact with source/drain regions of CMOS devices) and an overlying contact plug.

The essential dissimilarities between Jin et al. will be highlighted below, essentially citing claim 1 of the instant invention and by highlighting the most obvious differences:

1. the instant invention provides a method for forming a metal bump on a semiconductor substrate
2. the substrate has been provided with a contact pad; this contact pad is defined as and limited to a convention contact pad of aluminum or an aluminum compound
3. the contact pad sitting on an underlying layer of dielectric

4. creating an opening through an overlying layer of passivation having a first diameter, the first diameter of the opening being smaller than a surface area of the contact pad
5. etching the contact pad, using the layer of passivation as a mask, creating an opening in the contact pad
6. sputtering a layer of Under Bump Metallurgy (UBM) over the surface of the layer of passivation
7. electroplating a layer of bump metal
8. etching the layer of UBM, using the layer of bump metal as a mask; and
9. reflowing the surface of the layer of bump metal, forming the metal bump.

Jin provides for closely spaced contacts and for reducing series resistance of these contacts, the instant invention provides for repairing surfaces of contact pads that are potential damaged by frequent test probe contact. Jin creates an opening in a electrical point of contact, for instance the contact to a bit line of storage devices. Jin expands the circumference (or exposed surface) of the opening in order to increase contact surface area (and reduce interface resistance) with a there-over to be created plug and further provides ion impurity implantations in order to further reduce series resistance of the created plug. The instant invention addresses



a conventional (aluminum or copper or aluminum compound) contact pad and makes this contact pad reliable after the contact pad has been subjected to repeated contacts by a tester probe.

Dass et al. provides for creating a solder bump that can be used as an interface in testing a semiconductor device. Dass et al. does significantly not address the central aspect of the instant invention, that is the partial or complete removal of the contact pad in a surface area that has been exposed to impact by a tester probe. The use of a layer of polyimide, as provided by Dass et al., by the instant invention is only one aspect of the method of the invention whereby however the central objective and aspect of the instant invention remains the etching of the underlying contact pad in order to repair surface damage. This is clear from claim 8, which could be cited in detail at this time but which in many aspects follows the previously cited claim 1. The layer of polyimide is one of the possible variations that can be applied in etching the underlying contact pad.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 1-40 under 35 U.S.C 103(a) as being unpatentable over Applicant's

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admitted Prior Art in combination with Jin (US Patent 6,194,309) and Dass et al (US Patent 6,162,652) rejections be withdrawn.

#### Other Considerations

No new independent or dependent claims have been written as a result of this office action, no new charges are therefore incurred due to this office action.

#### SUMMARY

A new method is provided for the creation of metal bumps over surfaces of I/O pads. Contact pads are provided over the surface of a layer of dielectric. The aluminum of the I/O pads, which have been used as I/O pads during wafer level semiconductor device testing, is completely or partially removed over a surface area that is smaller than the surface area of the contact pad using methods of metal dry etching or wet etching. The contact pad can be accessed either by interconnect metal created in a plane of the contact pad or by via that are provided through the layer of dielectric over which the contact pad has been deposited. The process can be further extended by the deposition, patterning and etching of a layer of polyimide

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over the layer of passivation that serves to protect the contact pad.

It is requested that should Examiner not find the claims to be allowable that he call the undersigned Attorney at his convenience at 845-452-5863 to overcome any problems preventing allowance.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned:

**"Version with markings to show changes made."**

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'SBA', with a stylized flourish extending from the end.

Stephen B. Ackerman (Reg. No 37,761)

Version with markings to show changes made

IN THE SPECIFICATION

1) page 1, first paragraph, please replace this paragraph with the following:

This application is related to attorney docket number MEG01-001,  
filed on [\_\_\_\_\_] 01/16/01, serial number [\_\_\_\_\_] 09/760,909, assigned to a common assignee.

2) page 12, last paragraph, page 13, please replace this paragraph with the following:

Contact pads, having dimensions of about between about 60 x 60  $\mu\text{m}$  and 120 x 120  $\mu\text{m}$ , are in current practice frequently used as access or input/output contact points during wafer level testing of semiconductor devices. In view of the complexity and density of high performance semiconductor devices, these contact pads will, during a complete cycle of testing, [by] be contacted a number of times. Testing is as a matter of economic necessity performed at high speed, which frequently results in landing the test probe on the surface of the contact pad at high speed,

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resulting in mechanical damage to the surface of the contact pad. In a well controlled testing production line, the distribution of the probe marks (or the damaged surface area of the contact pad) is limited (controlled) to an area in the range of about 60 x 60  $\mu\text{m}$ . [This] Damage to the contact pad surface may occur in the form of a dent [in the surface of the contact pad] or may even become severe enough that the surface of the contact pad is broken, resulting in [the occurrence of] burring of [in] the surface of the contact pad. After the contact pads have [in this manner] been used as I/O points during high speed testing, a number of these contact pads are frequently used for the creation of solder or gold bumps over the surface thereof. In instances where the surface of the contact pad is damaged, it is clear that [the] this surface [of the contact pad] forms a poor basis [on] over which to create a solder bump or a gold bump. The invention addresses this concern and provides a method whereby surface damage to contact pads is removed.

IN THE CLAIMS

Please amend the claims as follows.

1. (Amended) A method for forming a metal bump on a semiconductor substrate, comprising the steps of:

providing a semiconductor substrate, said semiconductor substrate having been provided in or on the surface thereof with a contact pad, said contact pad sitting on an underlying layer of dielectric and being in electrical contact with at least one point of electrical contact in or on the surface of said substrate;

depositing a layer of passivation over the surface of said layer of dielectric underlying the contact pad, including the surface of said contact pad;

patterning and etching said layer of passivation, creating an opening in said layer of passivation having a first diameter, partially exposing the surface of said contact pad over a surface area of said first diameter, said first diameter of said opening created in said layer of passivation being smaller than a surface area of said contact pad by [a measurable] an amount;

etching said contact pad, using said layer of [pasivation] passivation as a mask, partially or completely first removing said contact pad from above the surface of said layer of

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dielectric, creating a opening in said contact pad having a diameter being about equal to said first diameter;

sputtering a layer of Under Bump Metallurgy (UBM) over the surface of said layer of passivation, including said opening created in said contact pad;

depositing and patterning a layer of photoresist, creating an opening in the photoresist with a slightly larger dimension than said first diameter;

electroplating a layer of bump metal in the photoresist opening;

stripping the layer of photoresist and etching said layer of UBM, using said layer of bump metal as a mask; and

reflowing the surface of said layer of bump metal, forming the metal bump.

2. (Amended) The method of claim 1 wherein said opening created in said contact pad has a depth that is less than a height of said contact pad by [a measurable] an amount.

8. (Amended) A method for forming a metal bump on a semiconductor substrate, comprising the steps of:

providing a semiconductor substrate, said semiconductor substrate having been provided in or on the surface thereof with

a contact pad, said contact pad sitting on an underlying layer of dielectric;

depositing a layer of passivation over the surface of said layer of dielectric, including the surface of said contact pad;

patterning and etching said layer of passivation, creating an opening in said layer of passivation having a first diameter, partially exposing the surface of said contact pad over a surface area of said first diameter, said first diameter of said opening created in said layer of passivation being smaller than a surface area of said contact pad by [a measurable] an amount;

depositing a layer of polyimide over the surface of said layer of passivation, including the opening created in said layer of passivation;

patterning and etching said layer of polyimide, creating an opening in said layer of polyimide having a second diameter, partially exposing the surface of said contact pad over a surface area of said second diameter, said second diameter of said opening created in said layer of polyimide being smaller than said first diameter by [a measurable] an amount;

etching said contact pad, using said layer of polyimide as a mask, partially or completely removing said contact pad from above the surface of said layer of dielectric, creating an opening in said contact pad having a diameter being about equal to said second diameter;



sputtering a layer of Under Bump Metallurgy (UBM) over the surface of said layer of polyimide, including said opening created in said contact pad;

depositing and patterning a layer of photoresist, creating an opening in said layer of photoresist with a slightly larger dimension than said second diameter;

electroplating a layer of bump metal in the opening created in said layer of photoresist;

stripping said layer of photoresist;

etching said layer of UBM, using said layer of bump metal as a mask; and

reflowing the surface of said layer of bump metal, forming the metal bump.

9. (Amended) The method of claim 8 wherein said opening created in said contact pad has a depth that is less than a height of said contact pad by [a measurable] an amount.

16. (Amended) The method of claim 15 wherein said removal surface area of said contact pad is smaller than a surface area of said contact pad by [a measurable] an amount.

17. (Amended) The method of claim 15 wherein said removal thickness of said contact pad is less than a height of said contact pad by [a measurable] an amount.

19. (Amended) The method of claim 15 wherein said partially removing said contact pad comprises the steps of:

depositing a layer of passivation over the surface of said layer of dielectric, including the surface of said contact pad;

patterning and etching said layer of passivation, creating an opening in said layer of passivation having a first diameter, partially exposing the surface of said contact pad over a surface area of said first diameter, said first diameter of said opening created in said layer of passivation being smaller than a surface area of said contact pad by [a measurable] an amount; and

etching said contact pad, using said layer of passivation as a mask, creating an opening in said contact pad having a second diameter, partially or completely first removing said contact pad from above the surface of said layer of dielectric, said second diameter of said first opening created in said contact pad being about equal to said first diameter of said opening created in said layer of passivation.

28. Please cancel claim 28.

29. Please cancel claim 29.

30. Please cancel claim 30.

31. Please cancel claim 31.

32. (Amended) The method of claim [28] 15 wherein said partially removing said contact pad comprises the steps of:

depositing a layer of passivation over the surface of said layer of dielectric, including the surface of said contact pad;

patterning and etching said layer of passivation, creating an opening in said layer of passivation having a first diameter, partially exposing the surface of said contact pad over a surface area of said first diameter, said first diameter of said opening created in said layer of passivation being smaller than a surface area of said contact pad by [a measurable] an amount;

depositing a layer of polyimide over the surface of said layer of passivation, including the opening created in said layer of passivation;

patterning and etching said layer of polyimide, creating an opening in said layer of polyimide having a second diameter, partially exposing the surface of said contact pad over a surface area of said second diameter, said second diameter of

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said opening created in said layer of polyimide being smaller than said first diameter by [a measurable] an amount; and

etching said contact pad, using said layer of polyimide as a mask, partially or completely removing said contact pad from above the surface of said layer of dielectric, creating an opening in said contact pad having a diameter being about equal to said second diameter.

34. Please cancel claim 34.

35. Please cancel claim 35.

37. (Amended) The method of claim [28] 15 wherein said contact pad is accessed by means of interconnect metal being provided in a plane of said contact pad and overlying said layer of dielectric.

38. (Amended) The method of claim [28] 15 wherein said contact pad is accessed by means of at least one via provided through said layer of dielectric.